Regionalism in the Western Hemisphere and Its Impact on U.S. Agricultural Exports: A Gravity-Model Analysis

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The last fifteen years of the twentieth century were marked by important achievements in the area of agricultural trade liberalization in the Western Hemisphere. In North America, Canada, Mexico, and the United States forged the North American Free Trade Agreement (NAFTA). This accord, which took effect on 1 January 1994, is dismantling most tariff and non-tariff barriers for trading between its members. NAFTA also incorporates the Canada-U.S. Free Trade Agreement (CFTA), an accord similar to NAFTA that took effect on 1 January 1989.

In addition, Mexico completed an agreement in 1986 to join the General Agreement on Tariffs and Trade (GATT). In conjunction with this action, Mexico implemented a series of unilateral reforms beginning in the mid 1980s that greatly increased outside access to the Mexican market. Because Mexico is one of the most important customers for U.S. agricultural exports, these reforms may be viewed as a predecessor to NAFTA, somewhat akin to CFTA.

In South America, Argentina, Brazil, Paraguay, and Uruguay created the Southern Common Market (MERCOSUR—Mercado Común del Sur) through the Treaty of Asunción, which took effect on 29 November 1991. In addition to progressively eliminating most tariffs between its participants, MERCOSUR features a common external tariff toward countries outside the common market. Chile and Bolivia became associate members of MERCOSUR in 1996 and 1997, respectively, which means that they share in the common market's project of internal trade liberalization but do not apply the common external tariff.

These agreements are now being followed by an even bolder initiative of hemispheric proportions. Since the Summit of Americas, held in Miami in 1994, the United States and thirty-three other democracies in the Western Hemisphere have been engaged in negotiations to create a Free Trade Area of the Americas (FTAA). Should these efforts bear fruit, the FTAA is likely to have an important impact on agricultural trade throughout the Hemisphere.

In this context, it is important to evaluate the impact of the Hemisphere's existing trade agreements. To this end, this paper employs a series of modified gravity models, as suggested by Cheng and Wall, to explore changes in U.S. agricultural exports to the members of NAFTA and MERCOSUR. The primary objective is to identify significant changes in this trade, both at the aggregate level and for individual commodities.

International Bilateral Agricultural Trade Database

The trade data utilized in this paper are drawn from a unique statistical resource called the International Bilateral Agricultural Trade (IBAT) database. This database reflects an innovative effort to choose among the competing trade statistics reported by member countries to the United Nations. Given the trade statistics of two countries for a particular year, the IBAT Database includes the figures from the reporting country with the larger share of reported trade that matches the reported trade of its trading partners. This evaluation is conducted on an annual basis at the four- and five-digit SITC level.

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The IBAT Database contains a substantial amount of commodity-specific information, an attribute that allows us to run separate models for total agricultural exports and specific commodities. Although the database includes observations as far back as 1965, we limit ourselves to the 1980–99 period, since the number of missing observations increases as one moves backwards in time through the data. Like most databases of bilateral trade, the IBAT Database lacks observations for those instances where trade equals zero or is not reported. To ensure that these observations do not drive the results of the models, a country's observations are included only if there are at least ten non-zero observations (out of fourteen) during 1980–93 and at least five non-zero observations (out of six) during 1994–99. This evaluation is conducted on a model-by-model basis. In addition, commodity-specific models are run only for those products where U.S. exports to all countries totaled at least \$100 million in 1999.

Econometric Model

In its most basic application, the gravity model posits that the value of exports from one country to another is a function of each country's Gross Domestic Product (GDP) and population, as well as the distance between the two countries. Additional variables may be included in order to address issues of concern to the researcher. Typically, the gravity model is estimated in log-log form using Ordinary Least Squares (OLS). However, as was mentioned above, the IBAT Database records no trade for many observations, particularly at the commodity level. For this reason, most of the gravity models in this paper are tobit models, as presented by Green (pp. 727–29):

$$(1) \qquad y^*_{it} = \beta' x_{it} + \varepsilon_{it}, \quad y_{it} = 0 \quad \text{if} \quad y^*_{it} \leq 0, \qquad y_{it} = y^*_{it} \quad \text{if} \quad y^*_{it} > 0$$

where y^*_{it} is latent measure of trade. The observed, dependent variable (y_{it}) equals the log of U.S. exports to country i in year t, as measured in thousands of U.S. dollars.

In addition to the intercept, the models in this paper contain a number of explanatory variables. The log of the importing country's GDP accounts for variations in trade due to the size of the importing economy. To construct this variable, GDP data (in billions of U.S. dollars) are drawn from the International Monetary Fund's World Economic Outlook Database. The *Statistical Yearbook of the United Nations* provides observations for countries not in this database.

Although population estimates are readily available in the *World Development Indicators CD-ROM* and the United Nations' *Demographic Yearbook,* we have opted not to include the log of the importing country's population in our models since this variable is closely correlated to the log of GDP. According to 1995 data, the correlation coefficient between the two variables is 0.70 for the countries in this paper's first model.

Following Cheng and Wall, the models include two vectors of fixed effects that respectively identify specific years and specific importing countries. Since the fixed effects for time capture the influence of any variable that does not vary by importing country, it is not necessary to include the log of U.S. GDP as an explanatory variable. Similarly, since the fixed effects for importing country account for the influence of any time-invariant factor, it is also not necessary to include distance.

Of primary interest are the dummy variables that indicate a country's participation in a particular trade agreement. Unlike most previous works, these variables are country-specific in order to address the possibility that the impact of a trade agreement varies among its participants. With respect to MERCOSUR, Argentina/1991–99 denotes U.S. exports to Argentina since the common market's initiation. Similar variables identify exports to Brazil, Paraguay, and Uruguay during 1991–99.

Another set of variables identifies exports to specific MERCOSUR countries during 1994–99. These variables are intended to capture the additional effect (if any) associated with the progressive reduction of tariffs within MERCOSUR. The selection of 1994 as the beginning of the period covered by these variables is by design, since 1994 is when NAFTA took effect. Thus, these variables may also capture NAFTA's influence on U.S. exports to the MERCOSUR countries. Two additional variables identify exports to Bolivia and Chile following their becoming associate members of MERCOSUR.

Four variables denote U.S. exports to Canada and Mexico during 1989–99. CFTA-Canada identifies U.S. exports to Canada during 1989–99, while NAFTA-Canada denotes U.S. exports to Canada during 1994–99. Thus, NAFTA-Canada captures the additional effect (if any) on U.S. exports to Canada associated with NAFTA's implementation. GATT-Mexico indicates U.S. exports to Mexico during 1989–99. The year 1989 is selected as the beginning of the period covered by this variable in order to account for the gradual implementation of Mexico's unilateral reforms. NAFTA-Mexico indicates U.S. exports to Mexico during 1994–99.

Before proceeding, it is important to emphasize that the trade-agreement variables may also capture the influence of other factors that are contemporaneous to these accords. For example, NAFTA-Mexico measures the influence on U.S. agricultural exports to Mexico during 1994–99 of not only NAFTA's provisions but also improvements to U.S.-Mexico transportation services, adjustments in Mexican sanitary and phytosanitary standards regarding U.S. exports, and so on.

Empirical Results

Total Agricultural Exports

Table 1 lists parameter estimates from the tobit model of U.S. agricultural exports (Model 1) and several alternative models. In addition to their estimation technique (OLS), Models 2–4 are distinguished from Model 1 by their smaller samples. Model 2 lacks observations for Equatorial Guinea—the one country that contributes observations to Model 1. Model 3 only includes countries whose agricultural imports from the United States exceeded \$100 million in 1993, while Model 4 employs the stricter limit of \$500 million. The purpose of the alternative models is to examine the robustness of the results when different sets of countries are included in the sample.

Table 1. Parameter Estimates for Gravity Models of Total U.S. Agricultural Exports

Variable	Model 1	Model 2	Model 3	Model 4
Number of observations	2,540	2,520	1,100	340
Number of left-censored observations	5	0	0	0
Intercept	12.7975***	12.7455***	12.4493***	12.8428***
Log of importing country's GDP	0.3183***	0.3232***	0.3868***	0.3123***
Participation in NAFTA or MERCOSUR				
CFTA-Canada (1989–99)	0.3758	0.3720	0.3444	0.3518**
NAFTA-Canada (1994–99)	0.3028	0.3070	0.1683	0.2564
GATT-Mexico (1989–99)	0.4987	0.4945	0.4618**	0.4752***
NAFTA-Mexico (1994–99)	0.3892	0.3925	0.2427	0.3437**
Argentina, 1991–99	1.0117**	1.0285**	n.a.	n.a.
Argentina, 1994–99	0.7019	0.6886	n.a.	n.a.
Brazil, 1991–99	−0.9025**	−0.8873**	−0.9359***	n.a.
Brazil, 1994–99	0.8627*	0.8502*	0.7023**	n.a.
Paraguay, 1991–99	1.5880***	1.6054***	n.a.	n.a.
Paraguay, 1994–99	0.2927	0.2786	n.a.	n.a.
Uruguay, 1991–99	0.0012	0.0183	n.a.	n.a.
Uruguay, 1994–99	0.6360	0.6217	n.a.	n.a.
Bolivia, 1997–99	−0.3799	−0.3627	n.a.	n.a.
Chile, 1996–99	0.1391	0.1422	−0.0485	n.a.
Fixed effects for importing country (compared with Canada)				
Argentina	−4.2950***	−4.2944***	n.a.	n.a.
Bolivia	−3.0016***	−2.9829***	n.a.	n.a.
Brazil	−1.8809***	−1.8841***	−1.8655***	n.a.
Chile	−2.4824***	−2.4711***	−2.3242***	n.a.
Mexico	−0.2212	−0.2178	−0.1725	−0.2254*
Paraguay	−5.5870***	−5.5698***	n.a.	n.a.
Uruguay	−4.9627***	−4.9485***	n.a.	n.a.
Scale	0.6710	n.a.	n.a.	n.a.
Log-likelihood (Model 1 only) or R^2	−2,595.8	0.9224	0.8913	0.9189

n.a. = not applicable.

Coefficients for fixed effects for year and some fixed effects for importing country are not reported.

Results of two-tailed t-test of parameter estimate's significance: ***Passes at 99% confidence level; ** passes at 95% level; and *passes at 90% level.

The coefficient for each trade-agreement variable measures the shift in the intercept associated with the observations denoted by that variable. A positive coefficient indicates higher levels of trade, while a negative coefficient indicates lower levels. As an example, consider exports to Canada during 1989–99. The coefficient for CFTA-Canada (0.3758 in Model 1) is the difference between the expected value of the latent trade variable y^*_{it} when CFTA-Canada equals one and its expected value when CFTA-Canada equals zero.

Of the four variables that denote exports to Canada and Mexico during the CFTA/NAFTA period, each obtains a positive coefficient in Models 1–4. However, none of these coefficients are statistically distinguishable from zero in Models 1 and 2, according to a series of two-tailed t-tests. When one-tailed tests are conducted, GATT-Mexico passes at the 10% level in both models. Additional variables become significant when the sample is sharply reduced. One-tailed tests indicate that CFTA-Canada and GATT-Mexico are significant at the 10% level in Model 3, and all four variables pass this test in Model 4. Despite the varying levels of significance, there is some consistency across the models in terms of the magnitude of the coefficients.

Table 2 contrasts the actual and expected values of U.S. agricultural exports to Canada and Mexico during 1989–99, based on Model 1. Following Green (p. 728), the expected value of the dependent variable (the log of exports to country i in year t) equals

$$(2) \qquad E[y_{it} \mid x_{it}] = \Phi\left(\frac{\beta' x_{it}}{\sigma}\right)(\beta' x_{it} + \sigma\lambda_{it})$$

where

$$\lambda_{it} = \frac{\phi(\beta' x_{it}/\sigma)}{\Phi(\beta' x_{it}/\sigma)}$$

and σ is the model's scale parameter. Given its relative simplicity, Model 1 does a reasonably good job of capturing the broad features of this trade.

By subtracting coefficient of Model 1 for GATT-Mexico (0.4987) from $\beta' x_{it}$ and then substituting this difference for $\beta' x_{it}$ in equation (2), one may calculate the expected value of U.S. agricultural exports to Mexico during 1989–93 when GATT-Mexico is held to zero. For exports during 1994–99, one may calculate the expected value when GATT-Mexico and NAFTA-Mexico are held to zero by also subtracting the coefficient for NAFTA-Mexico (0.3892) from $\beta' x_{it}$ when re-calculating the equation.

This simulation reveals that the gravity model attributes a great deal of influence to GATT-Mexico and NAFTA-Mexico. The former variable accounts for 39% of U.S. agricultural exports to Mexico during 1989–93, while the two variables together account for 59% of this trade during 1994–99 (table 2). These estimates are much larger than most assessments of NAFTA. For example, the U.S. Department of Agriculture's Economic Research Service

Table 2. Actual and Expected Values of U.S. Agricultural Exports to Canada and Mexico, 1989–99

	Exports to Canada		Exports to Mexico			
Year	Actual	Expected	Actual	Expected	Simulation	Share
	(in billions of dollars)					(in percent)
1989	3.74	3.80	2.95	2.57	1.56	39
1990	4.06	4.23	2.62	2.98	1.81	39
1991	4.33	4.28	3.06	3.17	1.92	39
1992	4.68	4.91	3.92	3.84	2.33	39
1993	5.00	4.55	3.72	3.71	2.25	39
1994	5.16	5.85	4.58	5.28	2.17	59
1995	5.41	6.53	3.62	5.13	2.11	59
1996	5.78	5.91	5.48	4.81	1.98	59
1997	6.46	6.56	5.49	5.60	2.31	59
1998	6.67	5.90	6.17	5.19	2.13	59
1999	7.02	5.58	6.19	5.03	2.07	59

Simulation indicates expected value if GATT-Mexico and NAFTA-Mexico are held equal to zero.
Share indicates the percentage of the expected value attributable to the GATT-Mexico and NAFTA-Mexico variables.

(1997) estimates that U.S. agricultural exports to Mexico were 3% higher in 1996 than they would have been in NAFTA's absence.

With respect to MERCOSUR, the gravity models suggest that the common market has negatively affected U.S. agricultural exports to Brazil. The coefficient for Brazil/1991–99 is negative and significant in Models 1–3, although the coefficient for Brazil/1994–99 partially offsets this effect. These results may be a sign of trade diversion due to MERCOSUR, as U.S. agricultural exports to Brazil grew more slowly during 1991–99 than corresponding exports to the world as a whole. For the other MERCOSUR countries, there is no evidence that the common market has reduced U.S. agricultural exports. In fact, the coefficients denoting exports to Argentina and Paraguay during 1991–99 in Models 1 and 2 are positive and significant.

An additional result of interest lies among the fixed effects for importing country. Each fixed effect for the MERCOSUR countries is negative and significant—a result that should not be surprising given that the excluded country for comparison is Canada. But the fixed effect for Mexico is statistically indistinguishable from zero. This finding suggests that the long-term U.S. trading relationship with Mexico is about as close as the long-term

Table 3. Overview of Commodity-Specific Gravity Models of U.S. Agricultural Exports

	Parameter					
Model	GATT-Mexico	NAFTA-Mexico	Argentina (1991–99)	Argentina (1994–99)	Brazil (1991–99)	Brazil (1994–99)
Total agricultural exports	Positive	Insig.	Positive	Insig.	Negative	Positive
Beer	Positive	Insig.	n.a.	n.a.	n.a.	n.a.
Cheese	Insig.	Insig.	n.a.	n.a.	Positive	Positive
Distilled alcoholic beverages	Insig.	Insig.	Insig.	Insig.	Positive	Positive
Cotton	Positive	Insig.	Insig.	Insig.	Insig.	Insig.
Flowers and foilage (cut)	Positive	Insig.	n.a.	n.a.	n.a.	n.a.
Fruit or vegetable juice	Insig.	Insig.	Positive	Insig.	Positive	Positive
Apples (fresh)	Positive	Insig.	n.a.	n.a.	Insig.	Positive
Grapes (fresh)	Insig.	Positive	n.a.	n.a.	Insig.	Positive
Corn	Insig.	Insig.	Insig.	Insig.	Insig.	Insig.
Rice	Positive	Insig.	n.a.	n.a.	Positive	Insig.
Wheat	Positive	Insig.	n.a.	n.a.	Negative	Insig.
Peanuts	Positive	Insig.	n.a.	n.a.	Positive	Insig.
Leather	Insig.	Insig.	Insig.	Insig.	Insig.	Insig.
Live poultry	Insig.	Insig.	n.a.	n.a.	Insig.	Insig.
Macaroni	Positive	Insig.	Insig.	Insig.	n.a.	n.a.
Beef (fresh or frozen)	Positive	Insig.	n.a.	n.a.	Insig.	Positive
Pork (fresh or frozen)	Positive	Insig.	n.a.	n.a.	n.a.	n.a.
Poultry (fresh or frozen)	Insig.	Insig.	n.a.	n.a.	n.a.	n.a.
Milk and cream	Insig.	Insig.	Insig.	Insig.	Negative	Insig.
Edible nuts	Insig.	Insig.	Positive	Insig.	Insig.	Insig.
Plants and bulbs (live)	Insig.	Insig.	Insig.	Insig.	Insig.	Positive
Prepared breakfast food	Positive	Insig.	Positive	Positive	Positive	Positive
Soda and bottled water	Positive	Insig.	n.a.	n.a.	Positive	Positive
Soybean oil	Insig.	Insig.	n.a.	n.a.	n.a.	n.a.
Soybeans	Insig.	Insig.	Insig.	Positive	Insig.	Insig.
Sunflower seed oil	Insig.	Insig.	n.a.	n.a.	n.a.	n.a.
Tobacco (unmanufactured)	Positive	Insig.	Negative	Positive	Insig.	Insig.
Tobacco products	Insig.	Insig.	Insig.	Insig.	Insig.	Insig.
Tomatoes	Positive	Insig.	n.a.	n.a.	n.a.	n.a.
Legumes	Insig.	Insig.	Insig.	Insig.	Negative	Positive
Wine	Insig.	Insig.	n.a.	n.a.	Insig.	Positive
Yarn and thread	Insig.	Positive	Insig.	Insig.	Insig.	Insig.

n.a. = not applicable.,
Sign of parameter estimate and estimate's significance according to a two-tailed t-test: Insig. = Insignificant at 90% confidence level; Positive = Positive coefficient, significant at 90% level; Negative = Negative coefficient, significant at 90% level. None of the parameter estimates for CFTA-Canada or NAFTA-Canada are significant.

relationship with Canada, once the size of the two economies and the differing impacts of GATT, CFTA, and NAFTA are taken into account.

Commodity Models

To further explore recent changes in U.S. agricultural exports, thirty-two additional models were estimated using the tobit method, each for a specific commodity or group of commodities. Table 3 summarizes the results of these models with respect to the trade-agreement variables. As a group, these models provide additional support for the hypothesis that Mexico's accession to the GATT has boosted U.S. agricultural exports to that country. GATT-Mexico obtains a positive and significant coefficient (based on two-tailed tests) in 14 commodity models: beer, cotton, flowers and foliage, apples, rice, wheat, peanuts, macaroni, beef, pork, prepared breakfast food, soda and bottled water, tobacco, and tomatoes.

In contrast, NAFTA-Mexico is positive and significant (based on two-tailed tests) in only two commodity models: grapes, and yarn and thread. When a one-tailed test is conducted, NAFTA-Mexico becomes a significant, positive factor for leather and tobacco products as well. The U.S. Department of Agriculture's Economic Research Service (1999, 2000) makes similar conclusions in its most recent biennial report on NAFTA. The report identifies Mexico's elimination of its import-licensing requirement for U.S. grapes as a noteworthy development and emphasizes the importance of NAFTA's rules of origin for textiles and apparel. These rules, which restrict NAFTA trade benefits to articles produced from yarn and fiber manufactured by NAFTA members, are likely to have increased demand for U.S. yarn and thread by Mexican textile and apparel producers. However, the report also concludes that NAFTA has boosted cotton and beef exports to Mexico. These products are absent from the list of commodities where NAFTA-Mexico is significant.

What is most surprising about the commodity models is that they generate no evidence whatsoever that CFTA and NAFTA have had a significant impact on U.S. agricultural exports to Canada. This broad finding may be due to the relatively low level of Canadian protection against U.S. exports that existed before CFTA. In any case, within the context of this paper's gravity models, the main explanatory factors of U.S. agricultural exports to Canada are the size of the Canadian economy and the historically close trading relationship between the two countries.

The finding that MERCOSUR has depressed U.S. agricultural exports to Brazil extends only to a handful of commodities. Brazil/1991–99 obtains a negative and significant coefficient only in the models for wheat, milk and cream, and legumes, and Brazil/1994–99 is not negative in any of the commodity models. Among the significant commodities, wheat is the most likely case of trade diversion. U.S. wheat exports to Brazil dropped from an annual average of $23 million during 1988–90 (the last three years prior to MERCOSUR) to just $4 million during 1997–99, while Argentine wheat exports to Brazil surged from $183 million to $801 million.

Conclusion

The gravity models in this paper highlight several important developments in the pattern of U.S. agricultural exports. First and foremost, exports to Mexico during 1989–99 were significantly higher compared with other observations in the sample. This result is obtained both at the aggregate level and for fourteen different commodities. Unilateral reforms by Mexico to open its market in the 1980s are likely responsible for the heightened level of this trade. However, the additional trade benefits secured by NAFTA appear to be less important to U.S. agricultural exports, providing stimulus only to grapes, yarn and thread, leather, and tobacco products. Thus, NAFTA's main benefit to U.S. agriculture was not to open the Mexican market further but to "lock in" previous reforms by Mexico.

None of the models associate the CFTA/NAFTA period with a significant change in U.S. agricultural exports to Canada. But the models do suggest that agricultural exports to Brazil may have suffered some trade diversion due to MERCOSUR. This finding is obtained at the aggregate level and for milk and cream, legumes, and wheat. Among these commodities, wheat is the most likely case of trade diversion, as Argentina has dramatically increased its share of the Brazilian wheat market.

Care must be taken in the evaluation of these findings, as the variables that denote a country's participation in a particular trade agreement also capture the influence of other contemporaneous factors. Incorporating additional variables that more fully describe international markets for specific agricultural commodities should improve the performance of the gravity models in this paper. Examples include volume measures of trade, actual transportation costs, and quantitative measures of trade impediments. Of course, additional data collection usually comes at a cost, and one of the main attractions of gravity models as they stand is that their data requirements are relatively small. The next generation of gravity models is likely to depart from this tradition.

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